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The Economics of RANCH FENCING IN HAWAII

PERRY F. PHILIPP

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THE AUTHOR

PERRY F. PHILIPP is Agricultural Economist at the Hawaii Agricultural Experiment Station and Professor of Agriculture, University of Hawaii.

PREFACE

The author wishes to express his appreciation to Hawaii's ranchers, dealers in fence materials, fencing and clearing contractors, state foresters and members of other state government agencies, without whose cooperation this study could not have been made. He also thanks C. W. Peters, agricultural economist, and D. M. Kinch, agricultural engineer, Hawaii Agricultural Experiment Station, for reviewing the manuscript.

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PHOTOGRAPH ON COVER

Men stretching woven wire with secondhand weapon carrier.

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SUMMARY

In 1958 and 1959, the author studied the economics of ranch fencing on a sample of Hawaiian ranches, which included more than half of the pastureland in the State. These ranches differed greatly in size and organization and in the kind and amount of labor and equipment used in fencing. Their fences were of several types and built under environmental conditions which varied greatly by type of ground, topography, rainfall, vegetative cover, and salt spray.

In constructing a new fence, these ranchers first built an access road, cleared the fence line, and made a road along the fence. Costs of these operations depended mainly on location, conditions, and equipment used.

Ranchers built mostly wire fences and occasionally stone fences and bulldozed log fences.

Based on the findings in the sample, the author compared typical costs of 11 major types of wire fences built in soil under identical assumed conditions. Costs of clearing and road building were not included in these fence costs.

The most common fence was made of four strands of wire with local wood posts set 10 feet apart. It cost $1,236 per mile to build, with annual costs of $203 in wet and $122 in dry climate. With wood posts 12 feet apart instead of 10, this fence, at 12 percent lower cost, was the cheapest to build among the sample fences.

A four-strand barbed wire fence with steel posts 10 feet apart had the lowest annual costs, 44 percent below those of the first fence in a wet climate and 26 percent lower in a dry climate. A popular barbed wire fence, with four steel posts set 10 feet apart between every two wood posts, cost about the same to build, but its annual costs were slightly higher. The same fence, built in rock instead of in soil, was 50 percent higher in both building and annual costs.

A fence built with 845 woven wire and an additional straight wire on top, with steel posts 15 feet apart, had annual costs only a few dollars higher than those of the cheapest barbed wire fence; however, its building costs were 23 percent higher.

New stone fences had substantially higher building costs than wire fences and only rarely had competitive annual costs. However, annual costs of old stone fences in earthquake-free locations were usually lower than those of wire fences.

Ranchers considered bulldozed log fences, which were essentially a by-product of pasture clearing, well worth making on low cost land, if trees of lasting quality were available.

Ranchers reduced fence costs by careful selection and volume buying of materials, by reducing costs of labor and equipment, and by substituting equipment and long-lasting materials for labor. They made use of government aid and up-to-date accounting methods such as choosing the most advantageous depreciation methods for tax purposes.

How good a fence they built depended on many factors such as their management practices, their willingness to take risks, their financial condition, their security of land tenure, and their plans and expectations for the future.

THE ECONOMICS OF RANCH FENCING IN HAWAII

by Perry F. Philipp

INTRODUCTION

Construction and upkeep of fences is a large cost item on Hawaiian ranches. Several types and qualities of fences are being used in Hawaii. In this study the major fence types are described and their typical construction and maintenance costs are calculated. Ways of reducing fence costs and the economics of deciding what quality of fence to build are summarized.

The fence costs calculated in the study are based on certain stated assumptions. Individual ranchers may find the costs for their fences by using the same methods of calculation which were used in this study; however, they need to make adjustments in the basic cost data, based on their specific location, and on the work pattern, materials, labor, and equipment which they used.

Noneconomic considerations may affect fencing decisions of some ranchers, such as wanting to be known in his area as the man who builds the best or the most expensive fences. These will not be discussed in this bulletin.

RANCHES IN HAWAII

Ranches in Hawaii vary greatly by size and type of ownership. The number of cattle ranches, number of cattle, and acreage used for pasture on January 1, 1960, grouped according to number of cattle per ranch, are shown in table 1. Only ranchers with herds of 20 or more cattle were considered as commercial ranchers and are included in the table.

The largest number of ranchers, 64 percent, had herds of less than 100 head of cattle. Most of them, though not all, were part-time ranchers. They had only 7 percent of all the cattle and 5 percent of all the pasture in the State. Another 20 percent of the ranchers, with herds of 100 to 499 head, had 10 percent of all the cattle and 6 percent of the pasture. Ranchers with 500 or more cattle amounted to only 12 percent of all ranchers, but they had 83 percent of the cattle and 89 percent of the pasture (fig. 1).

Ranchers owned about half of their pastureland; the rest was leased either from the government or from private landowners. Most ranches were run by the owner or lessor, but some of the large ones were operated by corporations under the direction of a hired manager.

TABLE 1. Number of commercial beef cattle ranches, number of cattle, and amount of pastureland in Hawaii, by size of ranch measured in number of cattle, January 1, 1960[1]

CATTLE PER RANCH	RANCHES		CATTLE		PASTURE	
Number	*Number*	*Percent*	*Number*	*Percent*	*Acres*	*Percent*
20– 49	151	38.5	4,400	2.7	28,000	2.6
50– 99	102	26.0	7,200	4.4	23,000	2.1
100–499	91	23.2	16,300	9.9	68,000	6.3
500–999	16	4.1	10,400	6.3	65,000	6.0
1,000 of more	32	8.2	126,200	76.7	895,000	83.0
Total	392	100.0	164,500	100.0	1,079,000	100.0

[1] Only ranches with herds of 20 head or more were considered commercial.
Source: Hawaii Cooperative Crop and Livestock Reporting Service.

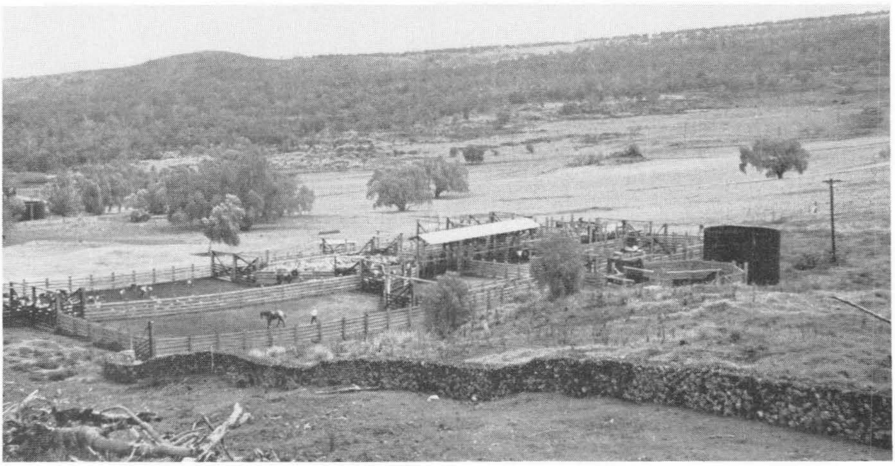

Fig. 1. Stone fence in foreground, headquarter corrals of large ranch in background.

METHODOLOGY AND SOURCES OF DATA

Much of the information in this bulletin was obtained from a sample of ranches. The sample ranches were selected with the advice of ranchers and county agents.

A purposive rather than a random sample was used, primarily because it was desired to include a nonproportionately large number of ranchers who used better-than-average fencing methods. Besides, as a result of the great diversity in the universe of Hawaiian ranches and the many different types of fences and environmental conditions, a large random sample would have been

TABLE 2. Number of ranches, cattle, and pastureland included in sample as percentage of state totals, by size of ranch

NUMBER OF CATTLE PER RANCH	NUMBER IN SAMPLE EXPRESSED AS PERCENTAGE OF STATE TOTAL IN THE SIZE CLASS		
	RANCHES	CATTLE	PASTURELAND
	Percent	*Percent*	*Percent*
20–499	5	10	5
500 or more	40	65	64
Total	9	55	57

necessary. Such a large sample could not have been handled with the financial and time resources available for the job.

The sample consisted of 36 ranches, 17 of which were of family size with a mean-size herd of 160 head. The other 19 sample ranches were large with a mean herd of 4,600 cattle.

The sample included 9 percent of all commercial ranches, but because of the high proportion of large ranches, it included more than half of the beef cattle and pastureland in the State (table 2).

The majority of the sample ranches were located on the island of Hawaii and some on the islands of Kauai, Maui, Molokai, and Oahu.

On the sample ranches information was gathered by various means. Cost records were gathered, fence lines were inspected, and fence construction was observed. Discussions were held with ranch managers, foremen, and workers.

Information was also gathered from landowners, suppliers of fencing materials, fencing and clearing contractors, state foresters, and members of other government agencies familiar with fence construction and upkeep. Most of the information was gathered during the years 1958 and 1959.

The information was used to synthesize costs of building and annual costs of different types of fences under assumed conditions closely comparable to the actual conditions on Hawaiian ranches.

CLASSIFICATION AND PURPOSES OF RANCH FENCES

Ranchers distinguished between border or outside fences and interior fences, which included cross or subdivision and wing fences. Corrals, a third type of fences designed as particularly strong enclosures of small, intensively used handling areas for animals, are not discussed in this publication.

Border fences, built to prevent animals from leaving or entering the ranch area, were usually the best constructed and most stockproof fences on the ranch.

Subdivision fences divided the total area of ranches into paddocks. Wing fences, short fences near gates, were erected to facilitate the driving of cattle.

The major purposes of interior fences were:

1. to separate animals by kind, sex, and age;
2. to permit development, rotation, and resting of paddocks;
3. to reduce the amount of labor required in handling cattle; and
4. to reduce the size of paddocks and thus assist in quieting and taming the cattle.

Border fences were always permanent fences; interior fences were sometimes temporary fences, which were erected for specific short-term purposes and dismantled when these purposes had been achieved.

THE HAWAIIAN SETTING

Ranch fences in Hawaii are built under greatly divergent environmental conditions. Many ranches, particularly the larger ones, extend from near the seashore to high up the mountain sides through different climatic, vegetation, and soil zones.

Rainfall

The amount of rainfall greatly affects the useful life of posts and wires. Ranch lands located on the lower leeward slopes and plains of the islands are, with few exceptions, arid or semiarid, with an average annual rainfall of from less than 10 to 35 inches (fig. 2). Pastures situated on the upper reaches of the highest mountains also get little rain. Ranches on the windward side of the islands and on some leeward mountain slopes receive moderate rainfall and in some places heavy rainfall of 100 to 200 inches (fig. 3).

Salt Spray

Salt spray carried in the air reduced the useful life of wires and steel posts. Damage from salt spray was serious only in relatively few windward locations exposed to continuous and strong tradewinds. Most of these places were in the lowlands fairly close to the seashore. In some areas, a reduction in the normal life of wires was reported at altitudes of several thousand feet at spots exposed to strong sea breezes. No damage was reported from the leeward sides of the islands, even for fences located only a mile or less from the sea.

Soil and Topography

The kind and topography of the ground affected the cost of fence construction. Ranch soils in Hawaii range from sandy soils to heavy clays and from soils without stones to pure rock (fig. 4). Rocks in lava flows range from *aa*, a rough, clinkery-surfaced rock, to *pahoehoe*, which is smooth- or ropy-surfaced hardened lava (fig. 5).

Generally, the stonier and rockier the soil, the longer it took to dig holes with hand tools and the costlier it was to use power-driven posthole diggers. Aa rock could usually be bulldozed fairly easily and holes could be dug with hand tools, while some pahoehoe was very hard rock, in which holes could only be made by blasting or with mechanical drilling equipment.

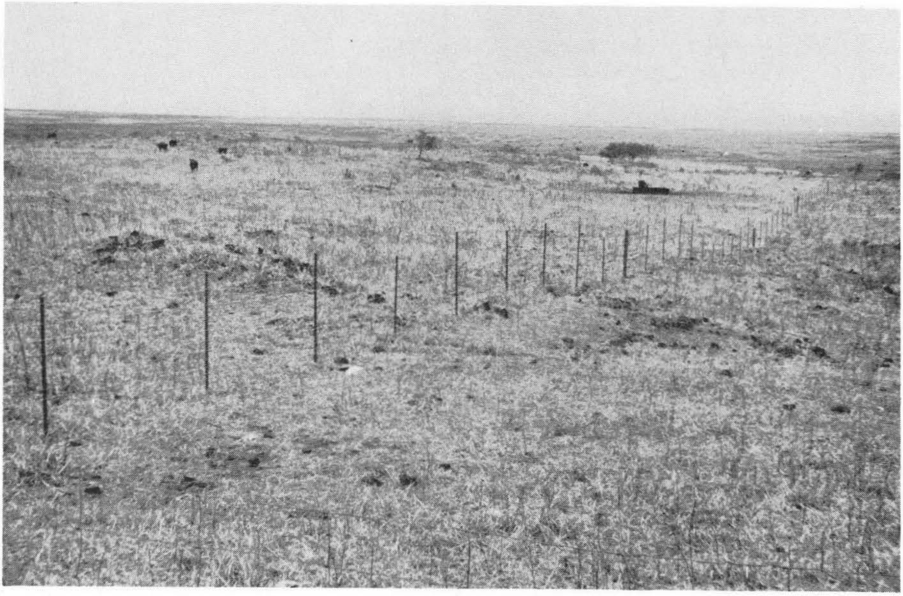

Fig. 2. Fence in low-rainfall area.

Fig. 3. Fence in high-rainfall area.

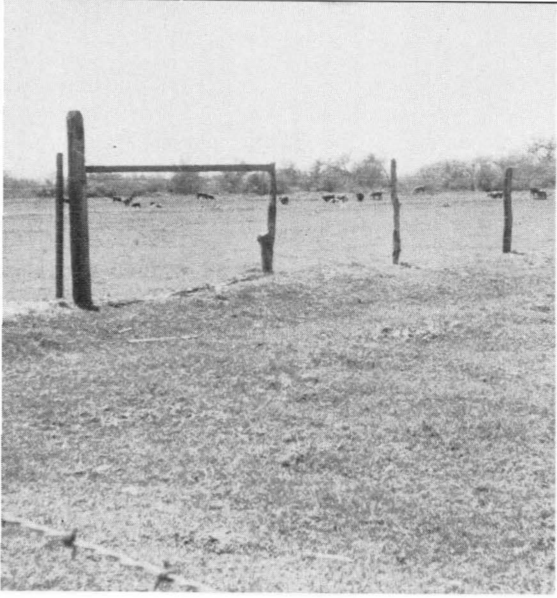

Fig. 4. Fence in sandy soil. Simple woven-wire gate at left. End post horizontally braced.

Fig. 5. Fence in pahoehoe lava. Steel posts, two barbed and two straight wires were used.

Hawaiian ranch lands ranged from completely flat areas to places where one narrow steep ridge followed the next, each being separated by a deep gulch.

Vegetative Cover

The natural vegetative cover of ranches varies from tropical forest with big trees and underbrush in the heavy-rainfall areas and lightly wooded parkland in some mountain pastures, to brush- and cactus-infested stretches and open grassland (figs. 2, 3, 6, and 7). Many areas are covered by comparatively recent lava flows, with or without sparse vegetation.

The type of vegetation affected fence costs. Heavy growth of trees increased the cost of clearing the fence line. Dense brush interfered with patroling the fence. On the other hand, in some areas trees which furnished good-fence posts grew near the fence line. Sometimes, rows of bulldozed trees could be used as a temporary fence line, and in some lava flows suitable rocks for a rock fence were available nearby.

Fence Labor

Hawaii's ranches varied greatly with regard to the type, quality, and quantity of labor and machinery used in fence building and upkeep.

On family-sized ranches, fences were built mostly by family labor and with the help of neighboring ranchers or temporary hired help. On large ranches, fences were usually constructed by fence gangs supervised by foremen or the manager (fig. 7). In addition, fences were built by contractors on both small and large farms.

Fence maintenance was usually done by two men working together and sometimes by one or by more than two men.

Payment to fence labor consisted of two parts—cash and fringe benefits. Very few ranchers had contracts with labor unions The level of cash wages depended mostly on the skill and experience of the worker, the type of job performed, the individual ranch and its location, and on the amount of fringe benefits paid. During the survey period, cash wages for ordinary fence workers ranged from a low of $0.77 for part-time high school boys to a high of $1.31 per hour. Most commonly, cash wages of $0.90 to $1.10 per hour were paid. Foremen and specialists, such as masons, carpenters, dynamiters, and sometimes drivers of large bulldozers, received higher pay. Since the survey was completed, cash wages have continued to rise.

Fringe benefits consisted of two parts—that required by law and that voluntarily supplied by ranchers.

Benefits required by law included the employer's social security contribution, workmen's compensation insurance, and unemployment insurance. The rancher's share of the social security tax amounted to $2\frac{1}{2}$ percent of the wage in 1958 and 1959 and to 3 percent in 1960. The cost of workmen's compensation insurance was 4.65 percent for annual payrolls of less than $25,000 and 1.42 percent for larger payrolls. Unemployment insurance, at the rate of 2.7 percent of wages paid, had to be paid only by ranchers subject to the Hawaii Wage and Hour Law. This law was applicable only to ranches with 20 or more employees or to ranches which were a part of a corporation employing 20 or more employees.

Among voluntary perquisites paid by ranchers were one or more of the following items: paid vacations, holidays, sick leave, old-age pensions, group life insurance, medical and dental insurance, housing, utilities, profit sharing, and Christmas presents. Certain food items were sometimes furnished free or at a discount, such as milk, meat, rice, and poi, or free land was made available for vegetable gardens. The value of these voluntary perquisites ranged from 0 to over $0.40 per hour of labor.

Fig. 6. Fence in parkland vegetation.

Fig. 7. Fence gang building a fence on a large ranch. Booms mounted on trucks used for handling posts.

Ranchers subject to the Hawaii Wage and Hour Law had to pay a minimum wage of $1.00 per hour. However, even on smaller ranches covered by the survey, the minimum hourly total wage for fence work, including both cash wage and fringe benefits, was rarely less than $1.00 and usually substantially higher.

The work week for fence workers usually ranged from five to six 8-hour days. Some ranchers worked half a day every Saturday and others worked a whole day every other Saturday. On ranches falling under the Hawaii Wage and Hour Law, 48 hours of work per week were allowed at regular wages for a period of 20 weeks. Overtime had to be paid on these ranches after 48 hours per week for 20 weeks and after 40 hours per week during the rest of the year.

Tools, Equipment, and Power

The following hand tools were most commonly used in fence work: cane knife, pick, and ax for clearing; *oo*, a Hawaiian tool, pick, and shovel for digging holes; a pipe to ram posts into the ground where this was done; block and tackle to stretch wires; a hatchet to clean rotted wood from posts; and a hammer to nail staples and nails.

Horses and mules were rarely the main means of transportation in bringing fence materials from the ranch to a fence under construction. They were sometimes used for auxiliary jobs such as to pull trees, which were to be cut into posts, out of the forest to the nearest jeep road. They were also employed occasionally to carry materials from the nearest ranch road to the fence line in rough terrain, where trucks could not enter. Even in these jobs, tractors were increasingly substituted for horses. However, horses were still widely used in checking existing fences and in making minor repairs, where no roads had been built along the fence and motor vehicles could not be used.

All ranchers included in the survey owned one or more vehicles, usually equipped with four-wheel drive. Many had bought used jeeps,[1] weapon carriers, trucks of various sizes, and trailers as army surplus at low prices. Some trucks and trailers were large enough to carry up to 100 posts per load.

The larger ranchers and the contractors usually used more specialized and heavier types of equipment than the smaller ranchers. They loaded posts with booms mounted on trucks or tractors and occasionally with hydraulically controlled tail gate hoists. Where the terrain permitted, they often unrolled and stretched wires with tractors or trucks, which were sometimes equipped with unrolling spools or power winches (photo on cover).

Clearing of fence lines and building of roads along the fence were almost entirely done with bulldozers, ranging in size from about 30 to 150 drawbar horsepower.[2] Postholes in soil were often dug with posthole diggers, which were either portable or driven by a two-plow-size wheel tractor. Compressors

[1] The reference to jeeps here or later does not constitute an endorsement of the vehicles bearing that trade name.

[2] In this bulletin, tractor horsepower values are those given as maxima in Nebraska Tractor Tests.

Fig. 8. Compressor mounted on tractor used in making postholes in rocky ground.

equipped with drills and jackhammers and mounted on tractors, trailers, or sleds were used to open up postholes in rocks (fig. 8).

One rancher used a pneumatic hammer, powered by a 50-horsepower tractor, to pound heavy steel rails into the ground. A crew of three put a post in place in 3 minutes with this machine.

Ranchers more and more substituted power saws for manually operated ones in operations such as cutting posts and building gates. In addition to all this machinery, many ranchers had specialized auxiliary equipment such as concrete mixers, welding tools, or vats to soak posts in preservatives.

ROAD BUILDING AND CLEARING OF FENCE LINE

The first steps in constructing a new ranch fence usually were building an access road, clearing, and building a road along the fence line (figs. 9 and 10). After completion of the roads, fence materials and workers could be moved quickly by jeep or truck to and along the fence line. Once the fence was built, the roads permitted quick and cheap fence inspection and upkeep by jeep. They also made easier the herding of cattle. Only in rough and rocky terrain or when financing was tight, have ranchers omitted building of fence roads during the last few years.

Fig. 9. Clearing fence line with large bulldozer.

Costs of land preparation were low in grassland and open country, where the ground consisted of soil. A bulldozer was used there only to even out the high and low spots along the fence line to make fence construction easier and to get a smoother road (fig. 11).

Costs increased with the amount and size of trees, the roughness of topography, and the amount and hardness of rock. Estimated contract costs in 1959 for bulldozing a jeep access road[3] to the fence for four different types of vegetation, rock, and topography are shown in table 3. A 124-drawbar-

TABLE 3. Cost of bulldozing a jeep access road to fence line under four different location conditions in 1959[1]

VEGETATION, TYPE OF ROCK, AND GRADE	BULLDOZING TIME PER MILE	CONTRACT COST PER MILE
	Hours	*Dollars*
Light tree growth, fairly smooth aa rock, level grade	8	120
Medium heavy tree growth and either rough aa and level grade or fairly smooth aa but steep grade	16	240
Medium heavy tree growth, pahoehoe (with top layer of rock not too hard), level grade	28	420

[1] Contract cost for a 124-drawbar-horsepower bulldozer, including operator, was $15.00 per hour.

[3] By jeep road is meant a rough road passable by jeeps or four-wheel-drive trucks, but not by ordinary two-wheel-drive cars or trucks.

horsepower bulldozer was used in all cases. Building such a jeep road under fairly difficult vegetation and rock conditions was $3\frac{1}{2}$ times as expensive as when light tree growth or easy rock conditions were encountered. Additional costs per mile to improve the jeep road sufficiently for use of a passenger car were estimated to range from $135 in aa to several thousand dollars in hard pahoehoe rock.

The additional cost of building a jeep road along the fence line after clearing was not large except under bad rock conditions. For example, it ranged from 10 to 20 percent of the cost of clearing a 25-foot-wide fence line in heavily wooded aa rock.

Usually ranchers put in one jeep road along a new fence (fig. 11). A few built a road on each side of the fence. These expected that the cost of the second road would more than pay for itself through reduced costs of transportation, fence upkeep, and cattle handling. Along old fences roads were still not common on many ranches.

The width of the strip cleared for a new fence ranged from 7 to 100 feet or more on the sample ranches. The 7-foot-wide swath was cleared by hand. In brushland some ranchers, mainly the smaller ones, cleared a 15- to 20-foot-wide line with enough space for a 12-foot-wide road. The width of the cleared strip about equalled the width of two bulldozer blades of a tractor rated at 70 drawbar horsepower.

Most larger ranchers preferred at least a 40- to 50-foot-wide cleared swath. This was about equal to the width of four dozer blades of a 124-drawbar-horsepower bulldozer. In stands of high trees ranchers sometimes cleared a 75- to 100-foot-wide line. In addition they cut down all trees which, while growing still farther away from the line, could have fallen on the fence in the future.

Cost of clearing a fence line usually varied with the size of equipment used. In table 4 the cost of clearing a 45-foot-wide fence line by hand was

Fig. 10. Fence line under construction in forest; 1047 woven wire is used.

Fig. 11. Completed 845-woven-wire fence in open country; 20 feet bulldozed on each side of fence with jeep road on one side.

compared with the cost of doing the same job with three different-sized bulldozers. The working time given was based on the experience of ranchers and contractors and hourly contract costs were those existing in 1959.

With hand-clearing costing more than twice as much as clearing with the smallest bulldozer used, it is evident why little clearing of fence lines was done by hand. Under the environmental conditions specified in table 4, clearing with large bulldozers cost less per mile than clearing with smaller ones. However, in some cases, particularly under marshy conditions, large bulldozers got stuck frequently and were more costly in use than smaller ones.

TABLE 4. Cost of clearing a 45-foot-wide fence line by hand and with bulldozers of various sizes[1]

TYPE OF EQUIPMENT	CONTRACT RATE PER HOUR[2]	MILE OF FENCE LINE CLEARED	
		WORKING TIME	CONTRACT COST
	Dollars	*Hours*	*Dollars*
Hand tools only	1.30	2,000	2,600
Bulldozer, 30 drawbar horsepower	6.00	190	1,140
Bulldozer, 42 drawbar horsepower	7.50	100	750
Bulldozer, 124 drawbar horsepower	15.00	28	420

[1] Clearing was assumed to be done in an area of medium heavy tree growth, rocky but dry ground, and fairly level topography.
[2] Both labor and equipment costs were included in the contract rate.

Most contractors and ranchers preferred two bulldozers to work together in clearing a fence line. Particularly in dense forests and in rough terrain, they expected up to 50 percent greater efficiency when the dozers teamed up than when they worked individually. The dozers combined forces or they pulled each other out when they got stuck. Sometimes two dozers of different sizes cooperated, such as one of 124 drawbar horsepower with another of 70 or 85 horsepower. The larger one contributed more power and the smaller one greater maneuverability. Besides, clearing fence lines was often a hazardous job; one driver could quickly come to the aid of the other in case of accident. Where a dozer operator worked alone, he was often assisted by a helper on foot, both for reasons of safety and for increased productivity.

BULLDOZED LOG FENCES

During clearing of a pasture, ranchers sometimes bulldozed trees into a continuous, compact line. Such a tree barrier, if dense and high enough, served as an effective fence. Major components of bulldozed log fences were often koa and ohia trees in the moist uplands and kiawe trees in the dry lowlands (figs. 12 and 13).

Building bulldozed log fences added little to the basic clearing cost, if many suitable trees were close at hand. Depending on the thickness of the

Fig. 12. Bulldozed koa fence in moist uplands.

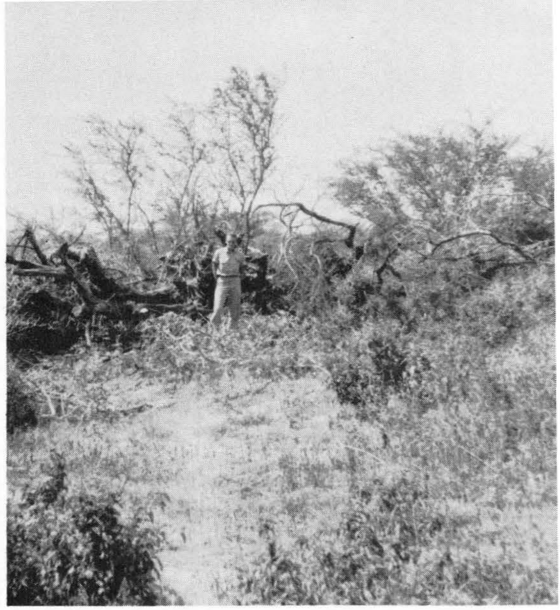

Fig. 13. Bulldozed kiawe fence in dry lowlands.

fence and the size and lasting quality of the trees used, such a fence lasted from a few years to as much as 10 years or more.

In view of their low original cost, bulldozed log fences are well worth making on low-cost land with a low carrying capacity such as dry tree-infested lowlands and heavily forested uplands. However, these fences take up much more space than other types of fences. The loss of potential grazing area makes them costly to use around pastures with a high carrying capacity.

As bulldozed log fences get older, the risk of cattle breaks increases. Some of the logs decay and these weak spots must be strengthened with short stretches of wire fence. Eventually it becomes cheaper to build a completely new wire fence than to keep up the old bulldozed log fence.

WIRE FENCES

Most ranch fences on the sample ranches were either wire or stone fences.

Materials

Posts

In most cases, the posts used in wire fencing had a shorter useful life than the wire. Posts were either imported or made from local trees. The useful life of wooden posts depended primarily on kind and quality of the wood, diameter of the post, preservative treatment given to it, and climatic conditions at the fence line.

Eucalyptus species, kiawe (*Algeroba chilensis*), and ohia lehua (*Metrosideros collina*) were the major local trees used for posts. One or more of these species were growing on most ranches.

Line posts ranged from 5 to 7½ feet in length. The average length of good line posts used in soil was 6½ to 7 feet. The longer posts were used as anchors in dips and hollows or occasionally in sandy soils. Shorter posts were often used in rocky ground, in low-quality fences, or when acquired secondhand such as railroad ties.

Line posts made from local trees were from 4 to 12 inches thick. Kiawe posts were usually from 4 to 8 inches and ohia and eucalyptus posts from 6 to 9 inches in diameter or more.

Corner posts were from 7 to 9 feet long and gate posts sometimes longer. They usually ranged from 9 to 20 inches in diameter, but kiawe corner posts as thin as 6 to 8 inches were occasionally found.

Eucalyptus: Several varieties of eucalyptus trees were used for fence posts, particularly *Eucalyptus robusta* (red gum or swamp mahogany), *E. globulus* (blue gum), and *E. tetracornis*. Expert fence builders choose mature trees at least 25 and preferably 40 years old. A typical 40-year-old *E. robusta* tree had a diameter of 30 to 35 inches at breast height and was about 150 feet high. It was used for posts up to a height of 100 feet, where it still had a 10- to 12-inch diameter.

Depending upon the variety, 7-inch-thick line posts cut from mature trees lasted from 5 to 7 years on the fence line in wet and somewhat longer in dry locations. Posts from immature trees had an average useful life of only 2 years in very wet and 3 years in medium wet locations. The bark was taken off in the case of most varieties, particularly those with a heavy bark such as *E. robusta*. Ranchers varied in their views on the advantage of drying eucalyptus posts before use. Usually, the posts were put on the fence line while they were still green, because the dry post became so hard that it was difficult to drive in staples.

Few ranchers treated their posts with preservatives before setting them in the ground. Fence line tests are now underway to check on the effectiveness of drying and of various treatments with preservatives. In one test a rancher found that *E. robusta* posts painted with pentachlorophenol had already lasted twice as long as unpainted controls and were still in the ground and in good condition.

Researchers of the University of Hawaii found in a test also still underway that eucalyptus posts treated with pentachlorophenol or creosote in cold baths or under pressure had lasted in the ground twice as long as untreated posts. Indications were that they might last 5 to 6 times as long as untreated posts. Since posts rot first at ground level and below, it might be sufficient to treat only the lower portion of the post.[4]

Ohia: When experienced ranchers used ohia posts, they preferred wood from trees 100 years old or older which had grown slowly in places such as lava flows and in not too moist a climate. They liked trees more than 12 inches wide at breast height and not below 7 inches wide at their smallest cross section.

Some ranchers interested in long-lasting posts preferred getting them from twisted- and curly-growing trees. They expected these posts to last at least 25

[4] Strohman, Robert E., *Preservative Treatments for Eucalyptus Posts*, Hawaii Agr. Expt. Sta. Bull. 114, 1957. Pp. 16–19.

percent longer than those cut from straight-growing trees. Other ranchers who wanted to get posts with the least possible labor input chose straight trees, which were easier to split.

Most, but not all, fence builders stripped the bark off ohia posts, because they believed that this would prolong their useful life.

Ohia end posts, 12 to 14 inches thick, and cut from mature "curly" trees, lasted 20 to 25 years in wet areas. In the same places good 6- to 7-inch line posts averaged 7 to 8 years, and 5-inch posts 4 to 6 years. Three-inch-thick posts, bark removed, and taken from fairly young trees grown in moist soil, lasted 3 years at best. Ohia posts lasted much longer in low- than in high-rainfall areas. For example, 7-inch posts lasted 15 to 25 years in a 20-inch rainfall area.

On one ranch, untreated ohia posts lasted 7 to 8 years in the ground. Identical posts lasted 2 to 3 years longer when brush-painted with a mixture of one part coal tar, two parts creosote, and 15 to 20 percent pentachlorophenol. Only the portion of the posts which was going to be in the ground or slightly above was painted.

Kiawe: Posts from kiawe trees were much in demand in the drier sections. The kiawe tree is similar in habitat and appearance to mesquite. In contrast to eucalyptus and ohia, kiawe tree trunks were neither split for posts nor was the bark taken off. Some ranchers soaked the posts in salt water, but most used them untreated. The outside pulpwood layer of kiawe posts soon rotted away, but the heartwood became very hard and long-lasting.

In dry areas, ranchers expected kiawe posts with a diameter of 5 to 7 inches to last at least 15 to 20 years in the ground. Thicker posts lasted even longer and were preferred for key positions in the fence line, such as corner or gate posts. In higher-rainfall areas, the life expectancy of kiawe posts was much shorter. Rancher experience ranged from 5 to 15 years for the 5- to 7-inch-diameter post with an average of 8 years.

Other local wood posts: Ranchers considered posts made from mamani trees (*Sophora chrysophylla*) the most durable of all. Old mamani posts were still standing in many fence lines, but few mamani trees for new posts were left in accessible locations.

Other trees were occasionally used for posts, particularly when they grew conveniently near the fence line. They were mainly koa trees (*Acacia koa*), brush box (*Tristania conferta*), coffee trees (*Coffea arabica*), and Java plum trees (*Eugenia cumini*).

Koa posts were long-lasting and used for gate and corner posts. Ranchers preferred posts from koa trees with dark wood or from dry dead trees.

Posts from the brush box tree lasted about as long as those made from eucalyptus. Posts from coffee trees rarely exceeded 6 inches in diameter and were not as durable as good ohia posts. Java plum trees were only used as a last resort because they did not last.

Cutting fence posts and delivering them to fence line: It was assumed here that line posts about 6 to 7 inches in diameter were cut from old ohia trees which were about 1½ feet in diameter at breast height. These trees yielded 20 to 25 posts each, of which about half were split.

Two men of average efficiency worked together as a crew. The following operations were included: selecting trees in the forest; cutting them down with a power saw, and debranching them; dragging them from their original location with a horse to a place accessible by truck; cutting them into 7-foot-long posts and removing the bark; splitting some of the posts with hand tools; loading the posts on a truck by hand; and transporting them to the fence line and unloading them (fig. 14).

Under these assumptions, labor time was 33 minutes per line post. Total cost per line post, including charges for equipment and transportation, amounted to \$.90. Total cost per corner and gate post, about 12 inches in diameter and 9 feet long, was \$1.80. Eucalyptus and kiawe posts cut under similar conditions would cost about the same as ohia posts.

Actual costs on the survey ranches per line post delivered on the line ranged from \$.36 to \$1.40. Major factors affecting cost were accessibility of the trees used for posts, their distance from the fence line, wage level, skill and efficiency of the labor crew, degree of mechanization, and cost of equipment use.

Imported wood posts: Redwood posts were the only kind of new imported wood posts used on the surveyed ranches. Line redwood posts were usually 4 by 5 inches in diameter and 7 feet long. Their main advantages were light weight and longevity; they were two or three times as light as most locally grown posts.

In wet areas a rancher could count on an average useful life of 20 to 25 years. Reports by ranchers ranged from a low of 7 to a high of 40 years or more in the ground.

In dry areas, redwood posts were often weakened by bumblebees which burrowed into the posts. In these areas, ranchers therefore expected an average life of only 15 years. Treatment with creosote and pentachlorophenol was sometimes given in recent years but no data on the increase in useful life were available on the surveyed ranches.

Fig. 14. Posts loaded on big trailer.

Fig. 15. Fence with two wire stays between every two steel posts.

Steel posts: The use of steel posts increased rapidly in recent years on the surveyed ranches, primarily because of their expected greater longevity and lower costs of installation and upkeep compared to most wood posts (figs. 5 and 15). In soil, steel posts did not require digging of postholes; they were driven into the ground with a pipe. In rocky ground, setting steel posts was much cheaper than putting in wood posts because of the smaller diameter of holes needed.

In ordinary soil, steel posts were used with heavy, riveted anchor plates. In hard pahoehoe some ranchers used them without these plates.

Ranchers usually bought painted steel posts. In high-rainfall areas, they sometimes gave these posts an additional coat of asphalt base paint or crude oil or they bought galvanized steel posts instead of painted ones.

Handling and transportation costs were much lower for steel than for wood posts because of their lighter weight and smaller volume. These factors were particularly important in building fences in inaccessible areas and in replacing individual posts.

On the basis of the few steel posts that had been in use for some time, ranchers expected them to last at least 20 to 30 years in wet areas and from 30 to as long as 50 years in dry areas. The life of steel posts was of course less in areas where salt spray was carried in the air.

An increasing number of ranchers built fences with three or more steel posts between every two wood posts (fig. 16). They combined the cheaper construction cost and longer life of the steel posts with the greater sturdiness of wood posts. After the wood posts rotted at ground level, they functioned as stays and the fence remained stockproof for some time.

Some ranchers hesitated to use steel posts, fearing that cattle would bend them. This did occasionally occur, but usually not in rough rocky ground or where steel posts were interspersed with wood posts.

Fig. 16. Fence with three steel posts between every two wood posts.

Fig. 17. Cement fence post.

Concrete posts: Concrete posts were still in use in some old ranch fences (fig. 17). Their measurements were usually 4 inches by 4 inches by 6 feet. Formerly they had sometimes been produced by a labor crew on contract, with the ranch supplying the materials.

Ranchers considered concrete posts to be "lifetime" posts, when used with quiet cattle. However, these posts would often break, if wild cattle would run head-on against them. The surveyed ranchers did not use concrete posts any more in new ranch fencing. Their main reason was that at 200 pounds per post they were too costly to handle.

Stays

Ranchers frequently used stays, also called spreaders, battens, hangers, or stringers. Stays were used to save posts and to keep wires at the same distance from each other and thus to prevent cattle from sticking their heads between them. They were usually thin pieces of wood, for example 2 by 3 inches in diameter, although on some ranches they were up to 6 inches wide. They ranged from 3½ to 5 feet in length. They did not enter the soil and therefore had a long useful life. They were often made of imported wood such as redwood and white pine (fig. 18). Sometimes old wood posts which had rotted at ground level were split up for spreaders. In inexpensive temporary fences, wood readily available along the fence line such as Java plum, guava (*Psidium guajava*), or koa haole (*Leucaena glauca*) was also used.

Wire stays were increasingly used (fig. 15). In comparison to wooden stays they had the advantage of smaller volume and less weight. Besides, they could be fastened quicker to wires and without the use of tools.

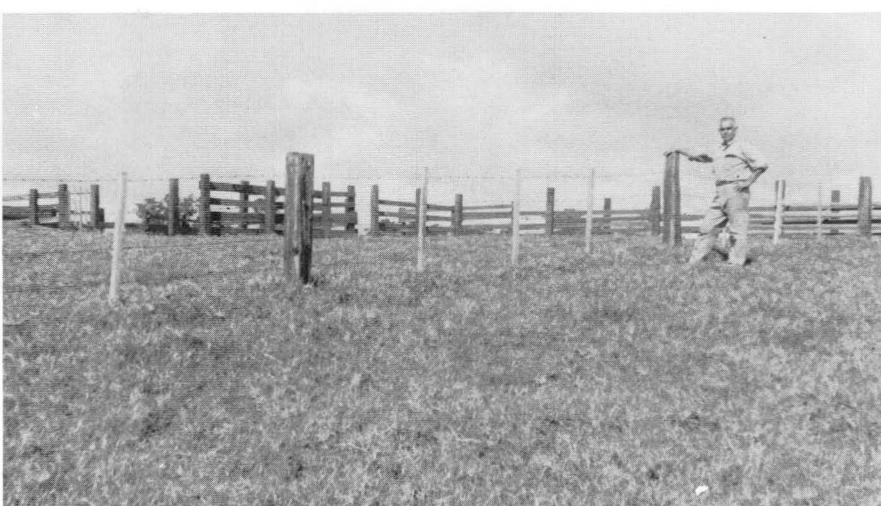

Fig. 18. Fence with three white pine stays between every two posts.

Wire

Barbed and straight wire: The majority of fences on the survey ranches were made of barbed or straight wire (figs. 5, 15, and 17). Barbed wire fences were generally more effective than smooth wire fences in containing cattle and in discouraging them from sticking their heads over and through the fence. Nevertheless, some of the larger ranchers had never used barbed wire in the past. They had feared injury from barbed wire to horses and to their rather wild cattle, particularly bulls. Lately, with more careful handling, cattle have generally become quite tame and many of these ranchers have started to use barbed wire in paddocks, where no horses are kept.

Most barbed wire was made of $12\frac{1}{2}$-gauge wire for the strands and of 14-gauge wire for the four-point barbs which were set 5 inches apart. Some old straight wire fences were made of 5-gauge wire. Ranchers built their new straight wire fences with 6- to 8- and occasionally 9-gauge wire. They ordinarily used heavier gauge wire on border and lighter gauge wire on interior fences.

While barbed wire did not last as long as straight wire, it outlasted most posts on the survey ranches. Barbed wire usually started rusting first at cut ends, where wires joined, where staples rubbed the wire, or where animals hit the wire and broke the protective zinc covering.

In moist areas, barbed wire was expected to last at least 20 years and often more, and straight wire 30 to 40 years. On some ranches in dry areas, barbed wire 35 years old and straight wire as much as 60 years old were still effective even though rusty. Ranchers sometimes rolled up wire from an old fence and re-used it on a newly built one as long as it was not rusty.

In areas where some salt spray was carried in the air, the expected life of a fence was cut to about a third. For example, one rancher expected barbed wire to last 8 years and straight wire 15 years in an area exposed to salt spray compared with 25 and 45 years, respectively, in unexposed locations. In a few highly exposed spots, wires had to be changed every few years.

Woven wire: The original cost of woven wire per mile of fence was much higher than that of barbed or straight wire. However, woven wire fences were stronger, required fewer posts, and had lower maintenance costs than barbed and straight wire fences.

With woven wire, posts could be set farther apart than with smooth and barbed wire. For example, ranchers stated that a woven wire fence with posts spaced 20 feet apart was about as stockproof as a fence made of five barbed wires with posts 10 feet apart.

A woven wire fence required fewer inspections than a barbed or straight wire fence. If a staple was lost in the latter type of fence with posts 10 feet apart, the wire could be moved a foot up and down. In contrast, the distance between horizontal wires was not affected in the case of woven wire even if three staples out of five per post dropped out. One woven wire fence remained quite effective although almost every other post had rotted at ground level.

Several types of woven wire were in use. In pre-World War II days ranchers often bought 747 woven wire. The number 747 means that the woven wire was made of 7 horizontal or line wires and that it had a width of 47 inches. The vertical or stay wires of the 747 were 24 inches apart and both line and stay wires were 6-gauge galvanized wire.

For new fences ranchers frequently bought 1047 woven wire, 47 inches wide and made of 10 horizontal wires (figs. 10 and 24). The stay wires were usually 12 inches apart for use with grown cattle and 6 inches apart for calves. The top and bottom horizontal wires were always 9-gauge wire. The remaining horizontal wires and the stay wires were 9-gauge for a strong, and 11-gauge for a weaker, version of this woven wire. Ranchers stated that with posts 10 feet apart, bulls could break the weaker type called "9 & 11" but usually not the stronger "9-gauge throughout" type of 1047 fence.

The lowest two horizontal wires in the 1047 were 3 inches apart. The distance between successively higher horizontal wires gradually increased until it reached 8 inches between the highest two wires. Some ranchers said that they did not need the lower horizontal wires so close together except where they wanted to keep wild pigs out of their pastures. They preferred the less expensive 845 woven wire, in which the lowest two wires were 4 inches, and the highest two 9 inches, apart (figs. 11, 29, 30, 31). While the 845 had two horizontal wires less than the 1047, it was only 2 inches narrower.

Others used the still more economical 635 woven wire, which was 35 inches wide and had 6 horizontal wires. A few built crucial border fences with 1155 woven wire—11 horizontal wires and 55-inch width. It was made of 9-gauge wire throughout.

On most survey ranches, woven wire fences were fairly new and had not yet been replaced. On the basis of their experiences up to the time of the survey, ranchers expected "9-gauge throughout" woven wire to last at least 30 years in wet and up to 50 years in dry areas, except where salt spray became a factor.

Staples

Staples ranged from 1¼ to 2 inches in length and were made from either 7- or 9-gauge wire. Ranchers seemed to prefer the longer staples, usually 1¾ inches long, for old and worn and for green and soft posts. In the case of the latter, the longer staples passed through the outer, quickly decaying layer of soft wood into the long-lasting heartwood.

Ranchers used the 1¼-inch-long, 7-gauge staples for hard posts, because these staples did not bend so easily and did not have to be driven so far into the wood. Staples were not hammered all the way into line posts, to allow the wire some room to play and to prevent breaking of the galvanizing on the wire; however, they were driven all the way into end and corner posts.

Gates

Gates varied from 9 to 18 feet in width. Ranchers wanted at least 10-foot-wide gates except where they used them only rarely and for small numbers of cattle. Even 10-foot-wide gates were not big enough for large bulldozers to pass through. Therefore, many ranchers recently built gates from 12 to 16 feet wide.

Some gates consisted simply of a piece of detachable woven wire and were used where there was little traffic (figs. 4 and 25). Wooden gates were most

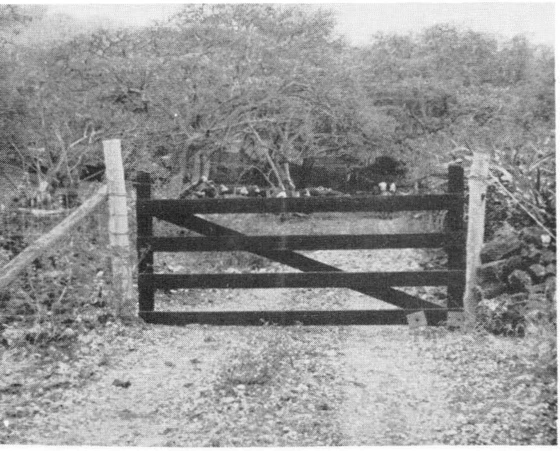

Fig. 19. Creosoted wooden gate.

Fig. 20. Aluminum gate in stone wall.

common. If unpainted, they lasted about 10 years in wet areas. If painted every 4 or 5 years with a wood preservative, they lasted about 20 years in wet and 25 years in dry areas (figs. 19, 20, and 32).

Aluminum gates became popular after World War II (fig. 20). Their original cost was higher than that of wooden gates, but they were expected to last longer. Ranchers said they were lighter and did not sag as much over time as wooden gates did, but they occasionally bent when hit by animals.

Other gates were built of steel or a combination of several materials such as wire, wood, and steel (fig. 21). For example, one low-cost gate consisted of woven wire strengthened by wooden planks and a pipe (fig. 22).

Fig. 21. Welded steel gate, built from scrap reinforcement steel.

Fig. 22. Inexpensive gate consisting of woven wire, strengthened by wooden planks and pipe.

Fence Characteristics

Post Distance

Distance between line posts depended mainly on purpose of the fence, type and quality of posts and wire, use of stays, type of soil and topography, kind and temperament of cattle, and preference of the rancher. Generally, posts were set closer in border than in cross fences, in rough topography than on even ground, in sand than in rock, for use with wild than with quiet cattle, and with poor rather than good quality posts.

For barbed and straight wire fences, the distance between line posts ranged from 7 to 15 feet, with 10 feet the most popular distance. Several ranchers preferred a distance of 8 feet. They pointed out that such a fence would still be quite serviceable even if one post in every two would rot and break. Sometimes, fences needed added strength such as near corners, gates, or at feeding and drinking troughs, where animals tended to crowd and push. In these places, ranchers would put posts, particularly steel posts, as close as 6 feet apart or connected them with wooden rails to distribute the load.

Where stays were used in straight or barbed wire fences, post distances usually ranged from 14 to 20 feet. The most common distance was 15 feet, with two stays between posts. At a post distance of 20 feet, the number of stays ranged from one to four. The greatest distance between line posts found in the survey was 40 feet, with three stays spaced 10 feet apart.

Post distances on woven wire fences were generally greater than for barbed and smooth wire fences, ranging from 10 to 20 feet.

Postholes

Holes for line posts in soil were usually 2½ feet and sometimes 2 feet deep. Occasionally they were 3 feet deep or more, such as in sandy soil or in dips and hollows. Wooden line posts when pounded manually into soft ground with a pipe were usually only 1½ feet deep in the ground.

Corner posts were mostly 3½ ft. deep in soil, with a range from 2½ to 5 ft.

In hard rock, ranchers found it difficult to make postholes without power equipment or blasting. In building low-cost fences in rocky ground, they sometimes fastened the fence wire to trees growing along the fence line (fig. 23). Since the sap of living trees corroded the wire, they occasionally attached wooden stays with wire to the trees and fastened the fence wire to them (fig. 24). Where trees grew too far apart, posts were set on top of the rocky ground and rocks piled around their base for support (fig. 23). For additional support, posts were sometimes put into 50-gallon drums filled with rocks or they were strengthened by guy wires which were fastened to railroad spikes driven into the rock (figs. 25 and 26).

In making postholes in rocky ground for better fences, compressor-driven drills or jackhammers and sometimes dynamite were used. Most ranchers preferred drilling to blasting, even if it was more expensive, because it resulted in better postholes.

In boring holes for steel posts in hard rock, ranchers often used a bit for their drill which was just about the width of the steel post or even a little narrower. The post wedged tightly into the hole had a strong footing (fig. 27).

Fig. 23. Wires attached to living tree and post set on top of rocky ground, with rocks piled around base of post for support.

Fig. 24. Stay attached to living tree with wire, and fence wire attached to stay. Note 1047 woven wire and additional straight wire on top.

Fig. 25. Post on top of rocky ground put into drum filled with rocks. Note low-cost woven wire gate.

Fig. 26. Post in rocky ground strengthened by three guy wires fastened to railroad spikes.

Fig. 27. Tight fit of steel post in hole drilled into rock.

Fig. 28. End assembly using wooden end and brace posts and wooden and wire braces.

Holes ranged from 6 to 20 inches in depth for line steel posts in pahoehoe rock and deeper in softer rock. Holes for corner and end posts in rock were usually from 2 to 3 feet deep. Some ranchers cemented the posts into the rock, while others did not.

Fence Height and Wire Distances

Five-strand border fences made from either barbed or straight wire or a combination of the two, ranged from 47 to 54 inches in height. Four-wire border and interior fences were usually 45 to 48 inches high. Three-wire fences were 3 feet high or higher. Woven wire fences ranged from 47 to 57 inches or more.

In barbed and straight wire fences, the lowest strand was from 6 to 15 inches above ground level, with many 12 inches above the ground. Distances between wires ranged from 9 to 12 inches.

Woven wire was installed anywhere from 3 inches or less to 12 inches above ground. Most ranchers strung one barbed or smooth wire anywhere from 2 to 8 inches above the top of the woven wire to prevent cattle from pushing down the woven wire from above (figs. 24 and 30); however, some dispensed with this additional wire (figs. 11 and 31).

End Assemblies

Corner and end assemblies on most ranches consisted of a wooden end or corner post, braced against a wooden brace post. Braces and trace posts were usually made of wood but sometimes also of steel rails (figs. 28 and 29). Occasionally, the whole corner or end assembly was constructed of steel (fig. 30).

Most fencers installed steeply sloping braces but horizontal ones were also used (figs. 4, 28–30). Corner posts were often of larger diameter than is customary in the mainland United States, but they were usually not anchored.

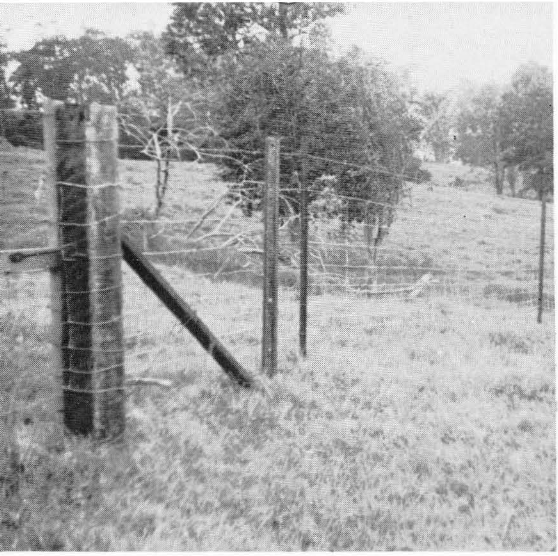

Fig. 29. End assembly using wooden end post and steel brace post and brace.

Fig. 30. All-steel corner assembly. Corner post is an old water pipe filled with cement and cemented into the ground. Braces are old rails welded to the corner post.

Length of Stretch

The length over which a wire was stretched at one time depended on topography, obstacles such as gates and corners, equipment used, type of wire, and preference of the fence builder. Generally, the longer the stretch, the less time it took to build the fence and the lower was the labor charge.

In flat terrain, when tractor- or truck-driven winches were used and there were no corners or gates, wires were sometimes stretched over a distance of half a mile. With hand tools, ranchers did not stretch more than a quarter of a mile at a time, which was the length of a coil of barbed wire. Where the topography was very rough, the average stretching distance was only 100 feet or less.

Some ranchers believed that they got an uneven stretch when they stretched woven wire over a long distance; they therefore preferred to stretch this type of wire only one coil (330 feet) or two at a time.

Anchors and Stockproofing

At dips of the fence line, posts and sometimes wires were anchored to prevent heaving of posts and to make the fence more stockproof (fig. 31). This was usually done by burying in the ground heavy stones or logs, called "deadmen," and by attaching them with wires to the post or to the fence wires.

Sometimes, depressions in the surface of the ground below the lowest fence wire were stockproofed with low stone walls, logs, or additional posts and wires. Stockproof water gates were constructed across streams. In rough country these various auxiliary structures added substantially to the cost of a fence.

Fig. 31. A fence anchor cemented into the ground at a dip of the fence line.

Typical Costs of Building Wire Fences

Assumptions

Based on the information gathered in the survey, typical costs were calculated of building 13 major types of Hawaiian ranch fences. The following assumptions were made in all these cost calculations: Every fence is 1 mile long. The topography is somewhat rough and requires stretching of fence wires every 660 feet (one-eighth mile). Every fence includes one 12-foot-wide wooden gate. Six corner, gate, or anchor posts are used per mile.

Materials are bought in small wholesale lots, such as 10 or more coils of barbed wire or 600 steel posts. Costs of materials include cost of transportation to the fence line and the 3½ percent state excise tax in cases where materials are purchased.

A crew of three men builds the fence. Some jobs such as digging holes for line posts in soil are done by one man. Other jobs such as setting and lining-up posts are done by two men. A third class of jobs such as stringing wires or hanging gates is done by all three men working together.

Labor costs are figured at $1.30 per hour, including the cost of perquisites. For every 7 hours of specified fence work, half an hour is charged for transportation of the workers to and from the fence line. Another half an hour per day is charged for miscellaneous unspecified fence-building labor. Workers are equipped only with hand or small power tools unless otherwise specified.

A weapon carrier acquired secondhand is used for transportation. It is kept at the fence line during the whole work day, but its engine runs only 1 hour per day.

Miscellaneous minor costs amount to 3 percent of all other costs. Included are such items as straight wire and wood used in making anchors or floodgates, dynamite or railroad spikes used in rocky ground, costs of using hand and small power tools, etc.

Costs of Building Barbed and Straight Wire Fences

Fence 1 is built with four strands of barbed wire and its line posts are set 10 feet apart on center in soil (table 5). Its posts are cut from island trees. Its corner, gate, and anchor posts, as in all the following fences built in soil, are 9 feet long and 3½ feet deep in the ground. Its line posts are 6½ to 7 feet long and 2½ feet deep in the ground. The total cost of constructing this fence is $1,236 per mile.

TABLE 5. Cost of building one mile of fence 1, a barbed wire fence, in Hawaii in 1959[1]

ITEM	UNIT	NUMBER OF UNITS	PRICE PER UNIT	COST PER MILE	
			Dollars	*Dollars*	
Materials					
Corner, gate, and anchor posts	Post	6	1.80	11	
Line and brace posts, and braces	Post	529	.90	476	
Barbed wire	Roll	16	13.20	211	
Staples	Pound	26	.20	5	
Materials for wooden gate	Gate	1	26.00	26	
Total material cost					729
Labor					
Constructing corner and gate assemblies and setting anchor posts	Hour	11	1.30	14	
Digging holes and setting and lining-up line posts @ 22½ minutes per post	Hour	197	1.30	256	
Uncoiling, stretching, nailing, and anchoring wires @ 0.9 minutes per running foot of fence	Hour	79	1.30	103	
Building and hanging gate	Hour	5	1.30	7	
Transportation time and miscellaneous labor	Hour	42	1.30	55	
Total labor cost	Hour	334			435
Weapon carrier					
Fixed cost	Hour	111	.10	11	
Variable cost	Hour	14	1.80	25	
Total cost of using weapon carrier					36
Miscellaneous costs figured at 3% of all other costs					36
Total cost					1,236

[1] This is a 4-strand barbed wire fence, using locally produced wood posts, with line posts set 10 feet apart on center in soil.

Fence 2 is like fence 1 except that it is built with five strands of 6-gauge straight wire instead of four strands of barbed wire (tables 6 and 7). The cost of the additional strand of wire makes this fence $174 per mile or 14 percent, more expensive than fence 1.

TABLE 6. Some major features and costs of building a mile of eight types of barbed and straight wire fences in Hawaii in 1959[1]

FENCE NUMBER	KIND OF LINE POSTS	LINE POST DISTANCE	STAYS BETWEEN POSTS	TYPE OF WIRE	STRANDS OF WIRE	TYPE OF GROUND	COST PER MILE
		Feet	*Number*		*Number*		*Dollars*
1	Local wood	10	None	Barbed	4	Soil	1,236
2	Local wood	10	None	Straight 6-gauge	5	Soil	1,410
3	Local wood	12	None	Barbed	4	Soil	1,090
4	Local wood	15	2	Barbed	4	Soil	1,115
5	Imported redwood	10	None	Barbed	4	Soil	1,833
6	Steel	10	None	Barbed	4	Soil	1,259
7	Steel and local wood	10	None	Barbed	4	Soil	1,257
8	Steel and local wood	10	None	Barbed	4	Rock	1,927

[1] Fences listed here are described further in the text. All fences have six wooden corner, gate, or anchor posts made of local wood and one wooden gate. All line posts are 6½ to 7 feet long except for 6 feet in fence 8. A weapon carrier is used. The only major piece of power equipment is used in fence 8. It is a 105 cc. compressor equipped with jackhammers and drills and mounted on a tractor.

TABLE 7. Material, labor, miscellaneous, and total costs per mile of building eight types of barbed and straight wire fences in Hawaii in 1959[1]

FENCE NUMBER	MATERIAL COSTS	LABOR COSTS	EQUIPMENT AND OTHER COSTS	TOTAL COST	TOTAL COST AS PERCENTAGE ABOVE OR BELOW COST OF FENCE 1
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Percent*
1	729	435	72	1,236	0
2	870	460	80	1,410	+14
3	649	378	63	1,090	−12
4	647	402	66	1,115	−10
5	1,327	434	72	1,833	+48
6	964	238	57	1,259	+ 2
7	919	278	60	1,257	+ 2
8	877	594	546	1,927	+56

[1] These fences are described in the text and in table 6.

Fence 3 differs from fence 1 by having its line posts set 12 instead of 10 feet apart. This reduces their number from 525 to 437, or by 88 posts. It also reduces the amount of labor needed to set line posts and to nail wires to the posts. Total cost of fence 3 is $1,090 per mile, or 12 percent less than the cost of fence 1. Fence 3 has the lowest construction costs of all the 13 fence types investigated here.

In fence 4 line posts are set 15 feet apart and two wooden stays are spaced evenly between them. The cost of line posts and of installing them is $243 or one-third less for this fence than for fence 1 because of the wider spacing of the posts. However, the additional costs of 705 stays, priced at $0.10 apiece, and of additional nailing labor and staples amount to $132. On balance, the total cost of fence 4 is $1,115 per mile, or 10 percent less than the cost of fence 1. The costs of fences 3 and 4 are thus quite similar.

Fence 5 is identical with fence 1 except that imported redwood line posts are substituted for locally produced wood posts. The use of redwood posts at $2.03 apiece instead of locally produced posts at $0.90 apiece raises the cost of the fence to $1,833 per mile. This is almost 50 percent more than the cost of fence 1.

In fence 6, steel line posts are substituted for the wooden ones in fence 1. A 6½-foot-long heavy duty, painted steel post including spade and clips to tie the fence wire costs $1.36 delivered at the fence line. Costs of these steel posts and clips are 50 percent, or $235 per mile, more than the cost of wood posts and staples in fence 1.

Driving a steel post into soil with a sleeve driver takes an average time of 7½ minutes. In the same type of soil, it takes an average of 22½ minutes, or three times as long, to install a wooden line post without power equipment. Labor costs of setting posts of fence 6 are $169, or 67 percent, lower than for fence 1. The total construction cost per mile is $1,259 for fence 6, only 2 percent higher than that of fence 1.

The construction of fence 7 is similar to that of fence 1 except that every wooden line post is followed by an average of 4 steel posts. Out of 521 line posts, 101 are made of wood and 420 of steel. Compared to fence 6, in which only steel line posts are used, material costs are lower and labor costs are higher, but the total cost of both fence types is practically the same.

Fence 8 is the same as fence 7 except that it is built in rock instead of in soil. The hardness of the rock varies over the length of the fence line as it often did on the surveyed ranches. A compressor equipped with two drills and jackhammers and mounted on a small crawler tractor is used where necessary in making postholes (fig. 8). The cost of renting and operating the compressor, exclusive of labor, is figured at $27 per day.

Corner, gate, and anchor posts are set about 3 feet and line posts 2 feet deep or less in the rock, depending on its hardness and the solidity of the footing. Because of the shallower holes, 6-foot-long steel posts are purchased instead of the 6½-foot-long ones used in soil. On the average it takes about 3½ hours to build a corner or end assembly, 1 hour to set a wooden line post, and less than half an hour to set a steel line post in this type of rock.

Fence 8 costs $1,927 per mile to build. This is 53 percent more than the cost of fence 7, its counterpart built in soil. Both labor and equipment costs are much higher in fence 8 than in fence 7, but material costs are lower, because of the shorter and thus cheaper steel posts.

Costs of Building Woven Wire Fences

In fence 9, 1047 woven wire is used with stays 12 inches apart (table 8). Top and bottom wires of this woven wire are number 9 gauge, and intermediate and stay wires are number 11 gauge. One barbed wire is strung above the woven wire. Wooden line posts are set 20 feet apart and the ground is soil. A weapon carrier with a winch mounted on it is used to stretch the wires.

Material costs of fence 9 are $260 higher than those of fence 1, primarily because of the high cost of the woven wire and the cost of an additional strand of barbed wire. Costs of line posts are lower for fence 9 than for fence 1, because the posts are set twice as far apart in fence 9 and therefore only half as many are needed.

Labor costs are $121 lower for fence 9 than for fence 1 because of the wider spacing of posts. Total cost per mile of building fence 9 is $1,372, or 11 percent higher than that of fence 1 (tables 9 and 10).

Fence 10 is exactly like fence 9 except that the single barbed wire above the woven wire is omitted. The cost of constructing a mile of this fence is $1,288, which is $84 less than the cost of fence 9, but $52 higher than that of fence 1. This fence has the lowest construction cost of the woven wire fences included in this investigation.

In fence 11 the 1047 woven wire is made of 9-gauge wire throughout and the posts are set 15 feet apart. Its cost is 17 percent higher than that of fence 8 because of the higher costs of the woven wire ($46 per roll) and the larger number of posts. Fence 11 costs 30 percent more than fence 1.

TABLE 8. Cost of building 1 mile of fence 9, a woven wire fence, in Hawaii in 1959[1]

ITEM	UNIT	NUMBER OF UNITS	PRICE PER UNIT	COST PER MILE	
			Dollars	*Dollars*	
Materials					
Corner, gate, and anchor posts	Post	6	1.80	11	
Line and brace posts, and braces	Post	266	.90	239	
Woven wire	Roll	16	41.00	656	
Barbed wire	Roll	4	13.20	53	
Staples	Pound	22	.20	4	
Materials for wooden gate	Gate	1	26.00	26	
Total material cost					989
Labor					
Constructing corner and gate assemblies and setting anchor posts	Hours	11	1.30	14	
Digging holes, setting and lining-up line posts @ 22.5 minutes per post	Hours	98	1.30	127	
Uncoiling, stretching, and nailing wires @ 1.1 minutes per running foot	Hours	97	1.30	126	
Building and hanging gate	Hours	5	1.30	7	
Transportation time and miscellaneous labor	Hours	30	1.30	39	
Total labor cost	Hours	241			313
Weapon carrier equipped with winch					
Fixed cost	Hours	80	.10	8	
Variable cost	Hours	12	1.80	22	
Total cost of weapon carrier					30
Miscellaneous costs figured at 3% of all other costs					40
Total cost					1,372

[1] A 9- and 11-gauge, 12-inch stay, 1047 woven wire is used with one strand of barbed wire strung on top. Locally produced wood posts are used, with line posts set 20 feet apart on center in soil.

Fence 12 is constructed with 845 woven wire, which is made of 9-gauge wire throughout at $39 per roll. One strand of number 7-gauge straight wire ($14.10 per roll) is stretched above the woven wire. Steel posts are used and set 15 feet apart.

The steel line posts and the strand of straight wire in fence 12 are more expensive than the local wood posts and the barbed wire strand in fence 11. However, the 845 woven wire used in fence 12 is cheaper than the 9-gauge 1047 woven wire used in fence 11. On balance, materials are $93 more expensive for fence 12 than for fence 11.

The labor needed to erect steel posts rather than wood posts is sufficiently less to make the cost of fence 12, at $1,552 per mile, about 3 percent cheaper than the cost of fence 11. Fence 12 is 26 percent more expensive than fence 1.

TABLE 9. Some major features and costs of building a mile of five types of woven wire fences in Hawaii in 1959[1]

FENCE NUMBER	KIND OF LINE POSTS	LINE POST DISTANCE	WOVEN WIRE TYPE	GAUGE WIRE USED	SINGLE WIRE ON TOP OF WOVEN WIRE	TYPE OF GROUND	COST PER MILE
		Feet					*Dollars*
9	Local wood	20	1047	9–11	1 barbed	Soil	1,372
10	Local wood	20	1047	9–11	No single wire	Soil	1,288
11	Local wood	15	1047	9 throughout	1 barbed	Soil	1,601
12	Steel	15	845	9 throughout	1 single, 7-gauge	Soil	1,552
13	Steel and local wood	20	845	9 throughout	1 barbed	Rock	1,728

[1] Fences listed here are described further in the text. All fences have six wooden corner, gate, or anchor posts made of local wood and one wooden gate. All line posts are $6\frac{1}{2}$ to 7 feet long except for 6 feet in fence 13. For all fences a weapon carrier is used. The one major piece of power equipment, a compressor mounted on a tractor, is used only for fence 13.

TABLE 10. Material, labor, miscellaneous, and total costs of constructing a mile of five woven wire fences in Hawaii in 1959[1]

FENCE NUMBER	MATERIAL COSTS	LABOR COSTS	EQUIPMENT AND OTHER COSTS	TOTAL COST	TOTAL COST AS PERCENTAGE ABOVE OR BELOW COST OF FENCE 1
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Percent*
9	989	313	70	1,372	+11
10	936	287	65	1,288	+ 4
11	1,144	376	81	1,601	+30
12	1,237	246	69	1,552	+26
13	1,033	416	279	1,728	+40

[1] These fences are described in the text and in table 9.

Fence 13, like fence 8, is built in rock. Four steel posts follow every wood post and a compressor equipped with drills and jackhammers is used to open up postholes. Unlike fence 8, woven wire 845 and one barbed wire on top are used instead of barbed wire exclusively. Line posts are set 20 instead of 10 feet apart.

Compared to fence 8, the cost of posts for fence 13 is lower as a result of their being spaced farther apart. However, the cost of woven wire is sufficiently greater than the cost of barbed wire to raise total material costs of fence 13 \$156 per mile above those of fence 8. On the other hand, as a result of wider spacing between posts, labor and compressor costs are lower for fence 13 than for fence 8. The total per mile cost of fence 13 is \$1,728, which is \$199 (or 10 percent) lower than the per mile cost of fence 8. Fence 13 is 40 percent costlier per mile than fence 1.

Annual Fence Costs

Annual fence costs consist of overhead and upkeep costs. Overhead costs of a fence in Hawaii are depreciation, interest, and real property taxes. They are fixed and unavoidable annual costs regardless of the amount of use of the fence. Upkeep costs arise only as long as the fence is being maintained.

Annual costs of wire fences in Hawaii are generally larger in wet than in dry areas because of the shorter life of fence materials in wet climates.

Annual Costs of Fence 1 in a Wet Climate

Depreciation: Let us assume that fence 1 (tables 5 and 11) is located in a wet area with an annual rainfall of 100 inches or more. Ohia line posts 6 to 7 inches in diameter are expected to last 7 years, ohia corner and gate posts, and gates to last 14 years, and barbed wire to remain in use 20 years.

The straight-line method of depreciation is used. The original cost of line posts and costs connected with these posts are depreciated over a period of 7 years, or at about 14 percent of their original cost per year (table 11). Corner

TABLE 11. Annual depreciation cost per mile of fence 1 in wet and dry climate in Hawaii in 1959[1]

ITEM	ORIGINAL FENCE COST	100-INCH RAINFALL AREA			20-INCH RAINFALL AREA		
		DEPRECIATION PERIOD	ANNUAL DEPRECIATION COST		DEPRECIATION PERIOD	ANNUAL DEPRECIATION COST	
	Dollars	*Years*	*Dollars*	*Percent of total*	*Years*	*Dollars*	*Percent of total*
Line posts, staples, setting posts, nailing wires, and proportionate share of transportation and miscellaneous costs[2]	936	7	134	89	15	62	85
Corner and gate assemblies and gate costs and proportionate share of transportation and miscellaneous costs[3]	64	14	4	3	25	3	4
Wire and stringing cost and proportionate share of transportation and miscellaneous costs	235	20	12	8	30	8	11
Total	1,236		150	100		73	100

[1] See table 5 for description of fence 1.
[2] Line posts are 6- to 7-inch-thick ohia posts in the wet area. In the dry area, they are 6-inch-thick kiawe posts.
[3] Corner and gate posts are 13- to 14-inch-thick ohia posts in the wet area. In the dry area, they are kiawe posts 10 inches or more in diameter.

and gate posts and gates are depreciated over 14 years, or at about 7 percent per year; and wires and costs of stringing them over 20 years, or 5 percent per year.

The original cost of line posts and associated costs amounts to 76 percent of the total original cost of the fence. However, 89 percent of the annual depreciation costs of the fence is line-post depreciation, because the useful life of line posts is lower than that of the other fence materials.

Interest: Interest is based on the half-depreciated or average investment of the fence (table 12). At an annual rate of 6 percent it amounts to $37 per mile per year.

TABLE 12. Annual costs of fence 1 in wet and dry climate in Hawaii in 1959[1]

ITEM	ANNUAL COST IN 100-INCH RAINFALL AREA		ANNUAL COST IN 20-INCH RAINFALL AREA	
	Dollars	*Percent of total*	*Dollars*	*Percent of total*
Depreciation	150	74	73	60
Interest at 6% on average investment	37	18	37	30
Real property tax at $16.50 per $1,000 of appraised value	7	4	7	6
Total overhead cost	194	96	117	96
Upkeep costs[2]	9	4	5	4
Total annual cost	203	100	122	100

[1] See footnotes of table 11.
[2] Before the fence was built, the line had been cleared and endangering trees had been removed. A jeep road runs along the fence.

Real Property Tax: The real property tax is calculated on the basis of 70 percent of the appraised value of the half-depreciated fence, which is $433. In 1959, the real property tax rate per $1,000 appraised value varied by counties from $15.15 for Oahu to $17.52 for Kauai. The average rate of $16.50 is used here, which coincides with the 1959 tax rate for the county of Hawaii. Based on this evaluation, the real property tax would amount to $7 per mile of fence 1.

Upkeep Costs: Upkeep costs consist of the costs of labor, materials, and vehicles or horses used in inspecting and repairing the fence. These costs are small in the first few years of the life of the fence, but they increase as the fence gets older.

It is assumed that the fence line was cleared before the fence was built and that all trees which had endangered the fence had been cut down. A jeep road runs along the fence.

Most of the costs of checking the fence periodically are charged to other jobs done on the same trip such as checking cattle, water, and grass growth. Under these assumptions, average upkeep costs are estimated at $9 per year.

If no road runs along the fence and therefore a horse has to be used instead of a jeep for transportation and if trees menacing the fence have not been removed, the upkeep cost of the fence is estimated at $17 per year. If the fence is poorly built or overgrown with vegetation or if wild cattle are run, upkeep costs run much higher.

The total annual cost of fence 1 in the wet climate is $203, which amounts to 16 percent of the original cost of the fence. Of the total annual cost, 74 percent is depreciation, 18 percent interest, 4 percent real property tax, and 4 percent upkeep cost (table 12).

Annual Cost of Fence 1 in a Dry Climate

Let us now assume that fence 1 is located in a dry area with an annual rainfall of 20 inches. Kiawe posts 6 inches thick are used and are expected to remain serviceable for 15 years (table 11). Kiawe line posts 10 inches or more in diameter are used as corner, gate, and anchor posts. They as well as the gate are estimated to last 25 years and wire to last 30 years.

The cost of building the fence as well as the annual interest and real property tax charges are assumed to be the same in the dry as in the wet area (table 12). However, annual depreciation and upkeep charges are lower in the dry area, because materials last longer.

Total annual costs are $122, or about 10 percent of the original cost of the fence. They are 40 percent less than the annual cost of the same type of fence in the wet area. Depreciation amounts to 60 percent of all annual costs in the dry area, compared to 74 percent in the wet area.

Annual Costs of Fences 2 to 13

Annual costs of all sample fences in both the wet and the dry area are summarized in table 13. Fence 2, with five-wire strands, has a slightly higher annual cost than fence 1, which has only four strands.

Fence 3, which with posts set 12 feet apart was lowest in construction costs among the 13 fences analyzed, did not have the lowest annual costs. However, its annual costs were 13 percent lower than those of fence 1.

Fence 4, with posts 15 feet apart and two stays between each two posts, had annual costs slightly higher than those of fence 3, but still lower than those of fence 1.

In fence 5 the redwood line posts are assumed to last 20 years in the wet areas. Despite their high original cost, their long useful life reduces the annual cost of this fence in the wet area below that of all the four preceding fence types.

In dry climate, redwood posts are assumed to last only 15 years because of a high incidence of bumblebee damage in the area. As a result the annual cost of this fence is higher in the dry than in the wet area—the only one of all sample fences where this is the case. The annual cost of fence 5 in a bumblebee-infested dry area is 50 percent higher than that of fence 1.

TABLE 13. Annual costs per mile of 13 sample fences in wet and dry climate in Hawaii in 1959[1]

FENCE NUMBER	INTEREST	REAL PROPERTY TAX	100-INCH RAINFALL			20-INCH RAINFALL		
			DEPRECIATION	UPKEEP	TOTAL ANNUAL COST	DEPRECIATION	UPKEEP	TOTAL ANNUAL COST
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1	37	7	150	9	203	73	5	122
2	42	8	154	10	214	76	5	131
3	33	6	129	9	177	63	5	107
4	34	6	133	9	182	65	5	110
5	55	11	93	4	163	113	5	184
6	38	7	64	5	114	42	3	90
7	38	7	81	6	132	48	4	97
8	58	11	131	7	207	77	5	151
9	41	8	108	6	163	58	3	110
10	39	7	102	6	154	55	3	104
11	48	9	128	6	191	68	3	128
12	47	9	63	3	122	44	2	102
13	52	10	89	4	155	56	3	121

[1] Fences are described in the text.

Steel line posts used in fence 6 are assumed to last 20 years in the wet and 30 years in the dry area. Their long life and low upkeep cost make this fence the one with the lowest annual costs of all. Its annual costs are 44 percent lower than those of fence 1 in the wet area and 26 percent lower in the dry area.

Annual costs of fence 7, in which a wooden line post follows four steel posts, are slightly higher than those of fence 6; however, they are still the second lowest among the barbed and straight wire fences.

Fence 8 is the same fence as fence 7 except that it is built on rocky ground. Its annual costs, both in the wet and in the dry area, are more than half again as large as those of fence 7.

Fence 9 is constructed with 9- and 11-gauge 1047 woven wire, a barbed wire above it, and local wood posts set 20 feet apart in soil. The woven wire is expected to last 30 years in the wet and 40 years in the dry area, compared to 20 and 30 years, respectively, for barbed wire.

Upkeep costs are lower for woven than for straight and barbed wire. Annual costs of fence 9 are 20 percent lower than those of fence 1 in the wet area and 10 percent lower in the dry climate.

For fence 10, which is just like fence 9 except for the omission of the barbed wire on top, annual costs are 6 percent lower than for fence 9.

Fence 11 is constructed with "9-gauge throughout" 1047 woven wire, a barbed wire on top, and local wood posts 15 feet apart. This quality of woven wire is expected to last 35 years in the moist and 45 years in the dry climate. The annual costs of this fence are approximately 17 percent higher than those of fence 9. Compared to fence 1, its annual costs are 6 percent lower in the moist and 5 percent higher in the dry area.

Fence 12 is made of 845 "9-gauge throughout" woven wire, a 7-gauge single wire on top, and steel line posts set 15 feet apart. As a result of the longevity of its materials, its annual costs are the lowest of all woven wire fences in the sample. Compared with barbed wire fence 6, which is the fence with the lowest annual cost and which also uses steel posts, its annual cost is only 7 percent higher in the wet and 13 percent higher in the dry area. Compared to fence 1, it is 40 percent lower in the wet area and 16 percent lower in the dry area.

Fence 13 is built with 845 woven wire, a barbed wire on top, and line posts made of steel and local wood set 20 feet apart in rock. Compared to fence 8, which is the barbed wire fence with steel and wooden line posts built on rock, its annual costs are 25 percent lower in the wet and 20 percent lower in the dry climate. Compared to fence 1, its annual costs are 24 percent lower in the wet and about the same in the dry climate.

STONE FENCES

Methods and Costs of Building Stone Fences

Stone fences were common on the survey ranches in rocky areas and over lava flows, particularly in the lowlands of Kona, Hawaii (fig. 32). Most of them were built many years ago, when labor was cheap. They were dry masonry walls usually from 3 to 4 feet high or higher and from 3 to 4 feet wide at the base, depending on the height and quality of the wall. Low fences had sometimes perpendicular walls, but the higher ones had sloped walls with a top width of at least 2⅓ feet. Except for mechanization in the clearing of the line and the quarrying, collecting, and transporting of stones, fences were still built by hand just as they had been built many years ago (fig. 33).

The cost of building a typical Kona rock wall for ranch purposes in 1959, excluding clearing costs, is shown in table 14. This wall is assumed to be 3⅓ feet high, 3⅓ feet wide at the base, and 2½ feet wide at the top.

The fence is built by a crew of three, of whom two are stonesetters and one is a helper. The workers spend half an hour in every 8-hour day travelling to and from the job. The average wage per worker is $1.30 per hour. A jeep is used for transportation and remains at the fence site during the day.

The availability of suitable stones at the fence site is a major factor affecting the cost of a stone fence. It is first assumed that stones are available nearby and can be transported to the building site with a wheelbarrow. Under these conditions, a fence costs about $3,900 to build per mile. Labor costs constitute all but about 6 percent of the total cost.

In 1959, some stone walls were built in Kona at a contract price of $0.50 per running foot. Even at this reasonable rate it cost $2,640 to build a mile of fence. This was substantially more than the cost of the most expensive sample wire fences (tables 7 and 10).

In some cases, old stone walls have fallen apart, but the stones have remained on the site and some of the foundation stones are still in place. The job of rebuilding such a fence is somewhat cheaper than the cost of the new fence just discussed. The cost depends on the amount of rebuilding necessary and on the amount of necessary clearing of trees which may have grown up on the fence line.

Fig. 32. Well-built stone fence and wooden gate.

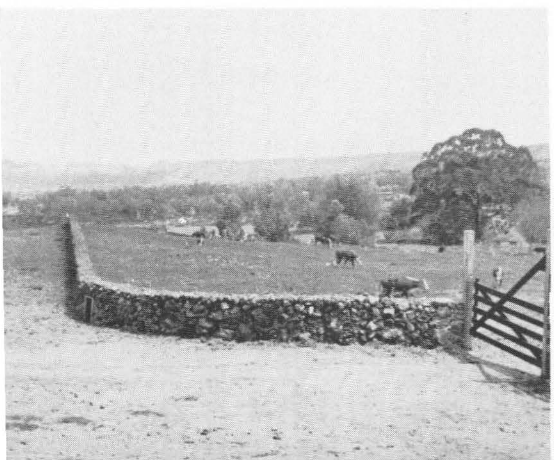

Fig. 33. Building and repairing stone fences is mainly done by hand.

TABLE 14. Cost of building a mile of stone fence in Kona in 1959[1]

ITEM	UNIT	NUMBER OF UNITS	PRICE PER UNIT	COST PER MILE
			Dollars	*Dollars*
Cost if stones available near fence line				
Labor:				
Construction[2]	Hour	2,640	1.30	3,432
Transportation[3]	Hour	176	1.30	229
Total labor cost				3,661
Jeep:				
Overhead cost[4]	Hour	939	.08	75
Operating cost[5]	Hour	59	1.80	106
Total jeep cost				181
Miscellaneous, including cost of building and hanging one wooden gate				60
Total cost if stones available near fence line				3,902
Cost if stones available 3 miles from fence line				
Delivering stones on contract[6]	Cubic yard	1,954	2.25	4,396
Total cost if stones available 3 miles from fence line				8,298

[1] This fence is $3\frac{1}{3}$ feet high, $3\frac{1}{3}$ feet wide at the base, and $2\frac{1}{2}$ feet wide at the top. Clearing costs are not included.
[2] A crew of three men builds the fence at the rate of 2 feet per hour per man.
[3] Transportation of labor to and from job at $\frac{1}{2}$ hour per day for 352 days.
[4] Jeep is at the disposal of the work crew during the entire construction period of 117 days.
[5] Jeep is operated $\frac{1}{2}$ hour per day for 117 days.
[6] Ten cubic feet or .37 cubic yards are needed per running foot.

Fig. 34. Loading stones into dump truck with front end loader.

Now let us assume that the stones have to be transported to the fence line over fair roads for a distance of 3 miles. The stones are gathered and loaded into a dump truck with a tractor equipped with a front end loader (fig. 34). With contract costs of $2.25 per cubic yard of stones delivered at the fence line, or $4,400 per mile, the total cost of the fence is $8,300 per mile.

Annual Costs of Stone Fences

A stone fence has the advantage over wire fences in that its material does not depreciate. Under normal conditions in dry areas, upkeep requires little labor. One man checking the fence and finding a break, only has to replace the fallen stones. He does not need to carry with him any tools or materials as he does for the repair of wire fences.

A strong earthquake may, however, flatten long stretches of stone fences and require a complete rebuilding job. This happened, for example, in 1951 and again in 1952 in some sections of Kona, when ranchers spent thousands of dollars rebuilding their stone fences. If another earthquake should occur, many ranchers may substitute wire fences for the damaged portions of their stone fences rather than rebuild the latter.

If it is assumed that a stone fence located in an area affected by earthquakes has to be rebuilt every 20 years, annual costs of the fence amount to $338, or substantially more than those of wire fences (tables 13 and 15). This explains why few ranchers have built new stone fences in Hawaii during the last few years.

The growing scarcity of good stonesetters is another factor working against the construction of many new stone fences. Building of stone fences is an art.

TABLE 15. Annual cost per mile of stone fence in Kona in 1959

ITEM	FENCE BUILT WITH STONES AVAILABLE NEAR FENCE LINE	FENCE WITH STONES TRUCKED 3 MILES TO FENCE LINE
	Dollars	*Dollars*
Original investment in new fence[1]	3,900	8,300
Depreciation at 5% per year[2]	195	415
Interest at 6% of average investment	117	249
Real property tax at $16.50 per $1,000 of appraised value	23	48
Total overhead costs	335	712
Upkeep costs	3	3
Total annual cost	338	715

[1] Original investment in fence is taken from table 14 and does not include the cost of clearing the fence line.
[2] A useful life of 20 years is assumed in the area in which damaging earthquakes occur.

Experienced stonesetters are getting on in age and there are few young trained men to take their place.

Where cheap and efficient labor is available, usable stones lie near the fence line, and earthquakes are improbable, annual costs of new stone fences may occasionally be competitive with those of new wire fences. Old stone fences in good condition in an area usually free of earthquakes are an asset to a ranch, since their annual costs are normally lower than those of wire fences. Thus, some landowners have stipulated in right-of-way proceedings that the highway department build them stone walls along the highways.

WAYS OF REDUCING FENCE COSTS

Hawaiian ranchers reduced their fence costs by such different methods as careful buying of materials, reducing costs of labor and equipment, making use of government aid, and choosing the most advantageous depreciation method for tax purposes.

Reducing Material Costs

Volume Buying

Costs of materials varied greatly, depending on the amount purchased at any one time. For example, ranchers paid about $14.50 per coil of American-made barbed wire in retail quantities of less than 10 coils. In small wholesale lots of 10 coils or more, they paid $13.20 per coil, or 9 percent less, and in carload lots $10.60 per coil, or 27 percent less than they paid at retail. A carload was 45,000 pounds, but only 20,000 pounds of this or 228 reels had to be wire. The remainder could consist of other steel products such as steel posts or staples.

Six-foot-long, heavy duty steel posts including spade and five clips cost $1.29 each, if bought in amounts of less than 100, and $1.01, or 22 percent less, if bought in carload lots. Redwood posts, 4 inches by 5 inches by 7 feet cost $2.20 apiece in lots of less than 100 and $1.54, or 30 percent less, in lots of 3,000 or more.

Large-scale buying required more management skill, planning, and effort than did "hand to mouth" buying of materials. The rancher had to become thoroughly familiar with the market for fence materials and had to be a shrewd buyer, because so much depended on every purchase decision.

In deciding how much to buy at one time, the rancher had to decide how much capital he could afford to tie up in fence materials not needed immediately. He also had to consider the availability of storage facilities and the possibility of losses or deterioration of fence materials during storage.

The rancher sometimes had to pool his purchases with those of other ranchers in order to get a substantial price discount. This cooperation with others required additional coordinating effort and risk taking.

Up to 2 months passed between the date of the order and the date of arrival of large-scale imports from the mainland United States and up to 4 months between order and arrival date of purchases from Europe.

Fence materials bought in large lots had to be picked up by the rancher at the dock. In contrast, small orders were immediately available at a dealer's warehouse or they were delivered free of charge at the ranch.

Despite these difficulties, large-scale buying of fence materials increased among Hawaiian ranchers during the last few years.

Choice of Type and Quality of Materials

Experienced ranchers reduced their building and annual costs of fences by a careful choice of the right type and quality of materials. For example, they used redwood posts in wet, but not in certain dry areas, and they chose kiawe posts for dry but not for wet locations.

Sometimes, material purchases made on the basis of custom or habit rather than careful planning resulted in avoidable expenditures. For example, some ranchers bought only 7-foot-long posts. That length was indeed required in the construction of a 4- to 4½-foot-high fence with posts set 2½ feet deep in the soil. However, in flat hard rock, with posts set 1½ feet deep, 6-foot-long posts were sufficient. In undulating land or where ground conditions varied, the purchase of several sizes of posts often saved money. An additional ½ foot in length increased the cost of steel posts by 6 to 8 percent.

Ranchers often used secondhand or slightly damaged new materials to good advantage in fencing. For example, steel rails from former plantation railroads, cut to size, made excellent braces and strong posts (fig. 30). They weighed 80 to 90 pounds and could be handled by one man.

Used water pipes, made of steel, were sometimes available from sugar mills. When filled with rocks and cement, they made strong and lasting corner posts (fig. 30). Old telephone posts and railroad ties, made of pine or redwood and treated with a wood preservative, also made good posts, provided the wood was still in good condition and, in the case of railroad ties, they were long enough.

Other ranchers bought steel scrap from old buildings for posts and gates or they purchased steel materials damaged by salt water in transit (fig. 21).

Reducing Labor and Equipment Costs

Substituting Materials and Equipment for Labor

Formerly it took much more labor to build and maintain ranch fences in Hawaii than it did at the time of the survey. In recent years, wage rates paid to fence workers have increased faster than prices of fence materials and equipment. As a result, many ranchers increased the relative share of material and equipment costs in total fence costs and reduced the cost share of labor.

For example, ranchers used more hog wire and less barbed wire than they did before. The purchase price of hog wire was higher than that of barbed wire, but hog wire fences required less upkeep labor than did barbed wire fences and they lasted longer. Many ranchers turned from local wood posts to steel posts, because the latter took less labor to install and maintain and they had a longer useful life than did the former.

Many ranchers greatly increased the productivity of their fence crews by equipping them with bulldozers, other motorized equipment, and power tools.

They were able to buy some of this equipment secondhand as surplus, primarily from the Armed Forces or from sugar and pineapple plantations.

They cut transportation costs by building fence roads. Communications inproved to a point where supervisory personnel on some ranches kept in touch with each other and ranch headquarters via radio telephones installed in their vehicles.

Crew Size

The optimum size of the working crew depended on the location and type of the fence, the character of the available labor force, and the size of the ranch. A three-man crew was more productive than a two-man crew or than a man largely working alone. Productivity per man often increased and building costs declined with larger crews because of greater job specialization and more intensive use of equipment and supervisory personnel. However, too-large crews became unwieldy and hard to coordinate, particularly when the crew members had little personal initiative and always waited for their foreman to tell them what to do.

Timing

Attention to right timing reduced costs of fence upkeep and fence building. Checking fences was often done while checking cattle, water, and grass or while on the way to or from another ranch job. It paid to have some fence repair tools and materials along in the jeep or on the horse and to make minor repairs on the spot, thus avoiding a special trip.

Good ranch managers planned building of fences during slack periods for their permanent labor force or when outside labor and equipment was available on favorable terms. They postponed some jobs such as gate building or treating of wood posts with preservatives for an occasional rainy day.

Temporary and Contract Labor

Several types of temporary labor were used by ranchers for fence construction. Some ranches were closely tied to sugar plantations. Field workers on these plantations were available for fence work when the sugar mill closed down during the off season. Other potential temporary fence workers were part-time ranchers and farmers, and high school students during vacations.

The employment of temporary labor, particularly if poorly trained, posed additional problems of labor organization and management for the rancher. However, it was one way for him to reduce his labor overhead and wage costs. At the same time, by providing additional employment opportunities, he strengthened and stabilized the economy of the surrounding area.

In recent years, building of ranch fences on contract became more important in Hawaii than previously. Ranchers made contracts for either the whole job of building a fence or for one or more of the following operations: clearing of the fence line, building of a road to and along the fence, cutting posts, bringing fence materials to the fence line, and erecting the fence.

In most contracts the rancher provided the purchased fence materials. In some he also furnished transportation and equipment, while the contractor only provided labor at a stipulated piece rate per post or per running foot.

Seasonal and temporary workers were primarily interested in the latter type of contract. Some ranchers preferred it to a wage relationship, because they believed that it reduced their labor management problems.

Sometimes construction, road-building, and land-clearing firms contracted with a rancher to build fences. These contractors provided both men and equipment. They owned bulldozers and other heavy machinery and were anxious to keep their equipment and crews working to hold their overhead costs down. If a rancher could bide his time until such a contractor was badly in need of a job, he was sometimes able to get his fence built cheaper and better than he could have done himself. The contractor probably had more specialized labor and equipment than the rancher could afford to keep for his occasional fence-building jobs.

Making Use of Federal Aid and Tax Regulations

A rancher could reduce his fencing costs by making good use of available government aid. Under the Federal "Agricultural Conservation Program for Hawaii" for 1959, the Federal Government paid a rancher 35 percent of the average cost of fencing materials at the farm and $0.25 per linear foot of rock wall.

This federal support was limited to $1,500 per rancher per year. To become eligible for it, the rancher became somewhat limited in his freedom of action. For example, his fence job had to be completed within a certain period. He had to use new wire and space posts not more than 16½ feet apart. Rock walls had to be at least 4 feet high, 3 feet wide at the base, and 2 feet wide at the top.

Choice of the most advantageous method of depreciation of the new fence for income tax purposes saved some ranchers money. For example, a rancher who was short of cash would choose a fast depreciation method. He used the declining balance method together with the additional first-year depreciation allowance of 20 percent of his total cost.

The resulting heavy tax deductions early in the life of the fence enabled him to keep for a time funds that he would otherwise have had to pay out as taxes. This in effect amounted to an interest-free loan to him equal to the tax savings during the first several years. The accelerated depreciation did not increase the total depreciation allowable over the life of the fence; it merely permitted the deductions to be claimed earlier than would otherwise have been possible.

If a rancher planned to sell his farm soon, he also gained by using a fast depreciation method. When the ranch was sold, the more rapid write-off of his fence costs increased his capital gains tax. However, he was still financially ahead, because the fast depreciation saved him tax payments at the normal rate, while his capital gains were taxed at only half or less of the normal rate.

A rancher who expected an increased income in the future and consequently taxation at higher tax rates, would gain by deferring to later as much of his depreciation allowance as possible. He would thus choose the straight-line method of depreciation which resulted in the lowest possible depreciation deductions during the early years of the life of the fence.

HOW GOOD A FENCE TO BUILD

From an economic standpoint the best fence was not necessarily the strongest, longest lasting, or best looking fence, but the fence which did the job adequately at the lowest cost. How good a fence to build depended on many factors such as the willingness of ranchers to take risks, their management practices, their financial condition, the security of their land tenure, and their plans and expectations for the future.

In general, the greater the risk of a fence break was and the less willing ranchers were to take that risk, the better a fence they built. They constructed strong fences where they were essential, such as to protect exposed borders, to separate weaned calves from their mothers, or to keep bulls away from cows. They built less costly fences around pastures which were used mainly for raising steers and heifers.

Good practices of handling cattle reduced the need for costly high quality fences. Tame cattle, which had become used to people from early youth and were frequently handled, were contained satisfactorily on some ranches by three-wire fences. In contrast, a strong, five-wire fence did not always hold wild cattle, which were afraid of people whom they only knew from branding and similar disagreeable operations.

The better the financial position of ranchers was, disregarding other factors, the better a fence they would build. Suppose a rancher had the choice of building a high or a low quality fence with a cost difference of $1,000 between the two. He had only $1,000 to spend above the cost of the low quality fence. By building the better fence, he expected average annual savings of $200 or a 20 percent return per year on his investment. Also, he had the alternative of investing the $1,000 in reseeding a pasture with an expected return of $400, or 40 percent per year.

Faced with a choice between his two investment opportunities, he chose the more profitable one, which was reseeding of the pasture. He thus built the lower quality fence. With an additional $1,000, or a total of $2,000 at his disposal, he would have both reseeded his pasture and built the better fence.

A rancher with secure land tenure, who expected himself and his family to stay on the property for a long time to come and who planned no changes in his ranch layout, would tend to build high quality and lasting fences. In contrast, a rancher who leased his ranch for 10 years without option of lease renewal or assurance of repayment of the undepreciated value of his fences, would only build fences with a 10-year life. The same would be true for a ranch owner who expected to sell or subdivide his land after 10 years.

The quality of a new fence depended also on the rancher's opinion of future business and economic trends. The more he expected fence costs to rise in the future and the more confidence he had in the future of his ranching business, the better and longer lasting fences he would build.

UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII
